

UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Survey
of
Hardeman County, Texas

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In cooperation with the
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SOIL SURVEY OF HARDEMAN COUNTY, TEXAS

By E. H. TEMPLIN, Texas Agricultural Experiment Station, in Charge, and T. W. GLASSEY, United States Department of Agriculture

COUNTY SURVEYED

Hardeman County is in the northern part of Texas, immediately south of Jackson and Harmon Counties, Okla. (fig. 1). Prairie Dog Town Fork Red River forms the northern boundary and Pease River a part of the southern boundary. Quanah, the county seat, is 125 miles northwest of Fort Worth. The total area is 693 square miles, or 443,520 acres.

Physiographically, Hardeman County lies within the Rolling Plains of Texas. It, therefore, lies near the eastern border of the Great Plains and between the High Plains on the west and the Grand Prairie on the east. The Rolling Plains of Texas consist of a comparatively smooth, somewhat dissected elevated plain which is cut by severely eroded belts along the main rivers, all of which flow eastward—that is, it includes broad, smooth, east-west interstream areas alternating with river “breaks.” The land slopes to the southeast, and the soils are developed on unconsolidated beds which dip to the northwest. In a few places, more resistant beds of sandstone or limestone occur, which outcrop in eastward-facing escarpments and break the major plain into several minor north-south plains.

The local topographic areas comprise (1) a strip of rough land about 3 miles wide on the south side of the county along the north side of Pease River, (2) a broad central east-west belt of comparatively smooth country, and (3) a high broad sand ridge about 3 miles wide on the south side of Prairie Dog Town Fork Red River. The central belt of smooth country slopes eastward and is cut into three minor plains by two north-south escarpments. The lowest of these plains is inextensive in Hardeman County and includes the section in the southeastern corner, locally known as “Farmers Valley.” The escarpment along the western limit of this lowest plain is formed

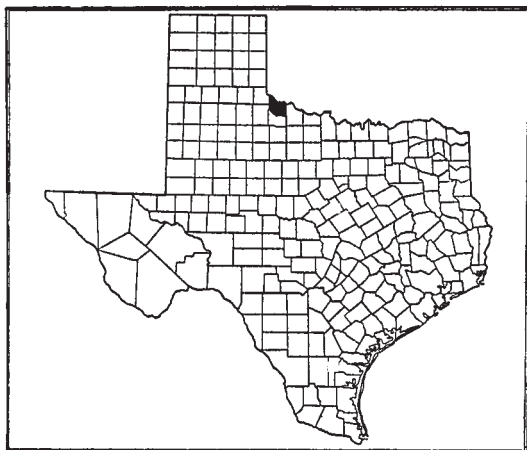


FIGURE 1.—Sketch map showing location of Hardeman County, Tex.

by sandstone and is about 40 feet high. It crosses United States Highway No. 370 about 4 miles east of Chillicothe and extends southwestward from that point. The next higher plain, the Chillicothe plain, is about 6 miles wide and extends from a point north of Chillicothe past the village of Medicine Mound to the vicinity of Star Valley School where it terminates at the edge of the breaks of Pease River. It includes a minor sand ridge, which is higher than the plain farther west, along the eastern rim south of Chillicothe. The escarpment or belt of sloping country bounding the Chillicothe plain on the west is a prominent topographic feature, constitutes a change in elevation of more than 100 feet, and is especially prominent in the bluff north of Lake Pauline, where it is narrow. The third and highest plain; the Quanah plain, extends westward from Quanah beyond the western edge of the county. The high land surrounding Herg and the mesas southeast of Lazare are outlying remnants of a still higher plain. The sand ridge along Prairie Dog Town Fork Red River is higher than the land in the interior of the county, and, although it has been modified by wind action, it is primarily a fresh-water deposit as is shown by the extensive deposits of water-worn gravel. Its higher elevation is owing to the slower erosion of the sandy material. These physiographic and topographic subdivisions are readily apparent in the small-scale map (fig. 2) showing the approximate distribution of soil groups in this county. The Quanah plain is divided into two soil groups and the Chillicothe plain into three.

The elevation of the county ranges from about 1,200 feet at the points where Prairie Dog Town Fork Red River and Pease River cross the eastern county line to 1,825 feet at a high point on the sand ridge along Prairie Dog Town Fork Red River about 2 miles south of Hooleyann. The elevation above sea level at Quanah is 1,563 feet.

Drainage is dominantly eastward through two main creeks, Groesbeck Creek and Wanderers Creek. Comparatively little territory drains directly into either Prairie Dog Town Fork Red River or Pease River. All sections, with the exception of a few small depressions, or "gyp sinks", on the plain west of Quanah, are reached by regional drainage lines. In most places well water is obtainable at a depth ranging from 50 to 100 feet, and the supply, in general, is sufficient for domestic and livestock use but not for extensive irrigation. In several communities the well water is of poor quality and has an extremely bad taste. The supply of well water is obtained at less depth and is more abundant in the eastern part of the county, especially around the lower edges of the sand belts. East of Goodlett, both branches of Groesbeck Creek are permanent streams having considerable flow of water which might be utilized for irrigation. Wanderers Creek is a permanent stream east of the seeps and springs about 2 miles southwest of Chillicothe.

According to the Federal census, the population of the county in 1930 was 14,532, 69.2 percent of which was classed as rural. The average density of the rural population at that time was 13.2 persons a square mile. The rural population is rather evenly distributed, except in the section known as the breaks of Pease River, which is very sparsely settled. Nearly all the people are native

whites. Quanah, the county seat and largest town, had a population of 4,464 in 1930, and Chillicothe had 1,610.

Quanah and Chillicothe are the principal local markets for farm products, and other trading points are scattered throughout the county. Quanah is an important cotton market and has a large

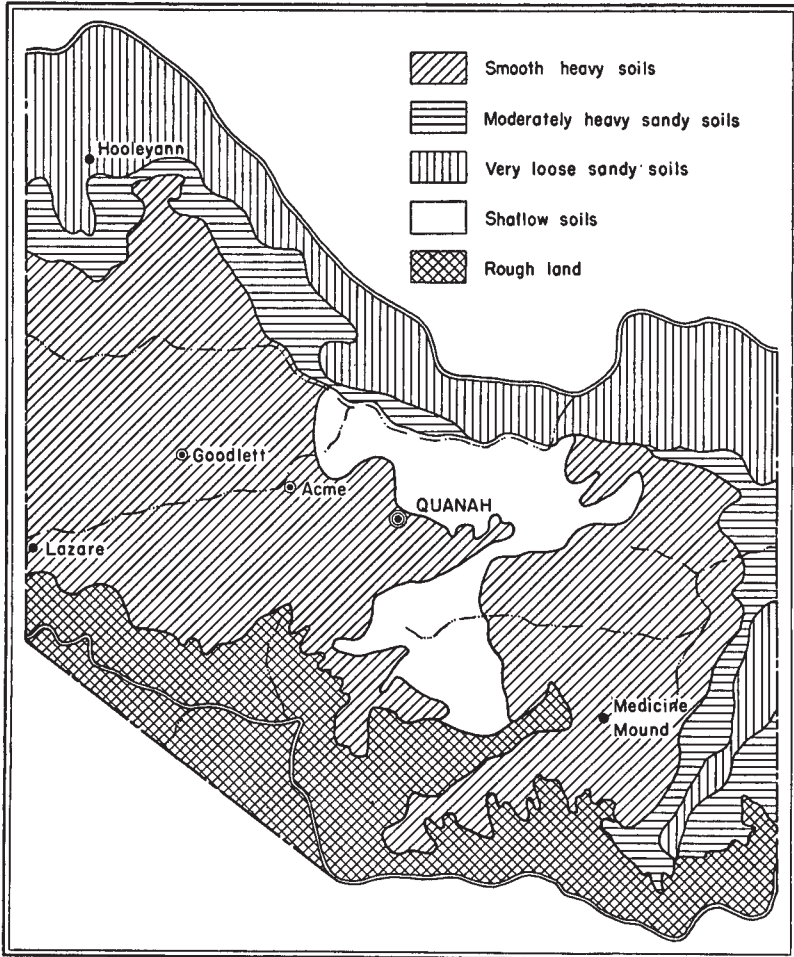


FIGURE 2.—Sketch map showing the distribution of soil groups in Hardeman County, Tex.

cottonseed-oil mill. Cotton gins are located at Quanah, Chillicothe, Goodlett, Lazare, and Medicine Mound. The gypsum mills at Acme constitute the principal industrial development in the county.

Transportation facilities are excellent. Good railroad outlets are available in all directions, and no section is more than 15 miles from a shipping point. The public-road system is good and includes two hard-surfaced main State highways, one paralleling the Fort Worth & Denver City Railway and the other running north and south through Quanah. Most of the county roads are graded, are well

maintained, and very seldom become impassable. Most sections are served with rural delivery of mail, a few farmers have telephones, and the public-school system is well developed.

CLIMATE

The climate is subhumid, warm, and of a continental type. The average annual rainfall of 24.41 inches is such that crop yields are determined largely by moisture conditions. Cultural practices are based primarily on methods for the conservation of soil moisture, and the most important soil characteristics from the point of view of crop production are those physical characteristics which determine moisture relationships. The crops capable of being grown here are limited by the climate to the drought-resistant types.

A pronounced dry season extends from about the middle of November to the middle of March. About four-fifths of the annual rainfall is received between the average dates of the first and last killing frosts. Although the average amount of rainfall during the warm season is approximately the same as that in the eastern and humid part of Texas, its distribution is more irregular and droughts are common. Rainfall in this section shows a distinct tendency toward cycles of several wet years followed by several dry years. Local showers and thunderstorms are the usual forms of rain during the summer.

The difference between the mean temperatures of the winter and summer seasons is about 40°. The winters are mild, with occasional cold spells, and during the summer the days are hot and the nights range from warm to cool. The average date of the latest killing frost is March 27 and of the earliest is November 6, giving an average frost-free period of 224 days. Frost has occurred as late as May 2 and as early as October 19. The length of the growing season is such that cotton commonly matures well before frost, and it allows considerable latitude in the optimum planting date for such crops as the grain sorghums and sorghos. Hardy vegetables grow throughout the winter, but fruit blossoms are very frequently damaged by late spring frosts.

The snowfall is very light and remains on the ground only a short time. The soil is seldom frozen for more than a day or so at a time, and the frost never penetrates below a depth of a few inches. Occasional hailstorms occur and damage crops over small areas. A large percentage of the days are clear, the atmosphere is dry and somewhat dusty, and the rate of evaporation is high. At Chillicothe the average annual evaporation from a free water surface is approximately 66 inches.¹ The average wind velocity is high, especially during the spring, when winds of sufficient intensity occur to drift the surface soil and severely damage crops, especially on the sandy soils, and in places to render extremely light loose sandy soils unsuitable for cultivation.

Table 1, compiled from the records of the United States Weather Bureau station at Quanah, gives the more important climatic data for Hardeman County.

¹ KARPEN, R. E., QUINBY, J. R., JONES, D. L., and DICKSON, R. E. GRAIN SORGHUM DATE-OF-PLANTING AND SPACING EXPERIMENTS. *Tex. Agr. Expt. Sta. Bull.* 424, 71 pp., illus. 1931.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Quanah, Hardeman County, Tex.*

[Elevation, 1,563 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1910)	Total amount for the wettest year (1919)	Snow, average depth
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
December.....	41.8	83	-6	1.06	(1)	0.10	1.8
January.....	40.6	84	-6	.51	0.30	.20	1.5
February.....	44.6	93	-6	.71	.46	.45	2.4
Winter.....	42.3	93	-6	2.28	.76	.75	5.7
March.....	53.3	102	12	1.45	.40	1.96	2.5
April.....	62.8	104	23	2.52	1.38	4.43	(1)
May.....	70.8	111	31	2.97	3.09	8.62	.0
Spring.....	62.3	111	12	6.94	4.87	15.01	2.5
June.....	80.3	112	42	3.85	.25	4.05	.0
July.....	84.2	111	55	2.40	2.41	3.75	.0
August.....	83.3	112	50	2.31	1.61	3.60	.0
Summer.....	82.6	112	42	8.56	4.27	11.40	.0
September.....	76.6	109	36	2.63	1.55	2.60	.0
October.....	64.8	100	24	2.92	.32	9.02	.0
November.....	52.9	95	5	1.08	.83	1.15	.6
Fall.....	64.8	109	5	6.63	2.70	12.77	.6
Year.....	63.0	112	-6	24.41	12.60	39.93	8.8

¹ Trace

AGRICULTURE

Cattle ranching, which was the first agricultural pursuit in Hardeman County and the surrounding country, began about 1878. The heavy growth of nutritious grasses, the mild climate, and cheapness of the land made this section especially suitable for livestock raising. At first the ranchers depended solely on the native grasses for livestock feed, and the farming consisted only of growing a few vegetables and cutting some of the native grasses for hay.

About 1890, large areas of land began to be broken and placed under cultivation, and at this time wheat and corn were the most important crops. Cotton became an important crop about 1900, and the grain sorghums were introduced shortly before 1910. Since the introduction of grain sorghums, very little corn has been grown. By 1910, nearly one-half of the land well suited to crop production was in cultivation, and the value of crops produced was more than twice the value of livestock raised. Some cattle ranching is still carried on, but the area devoted to that type of agriculture has continually decreased until it is now confined almost exclusively to soils unsuitable for cultivation. Since 1910 the two cash crops—cotton and wheat—have constituted the principal agricultural products. The acreage devoted to these two crops has differed widely in different years, but since 1924 cotton has occupied at least two-thirds of the total area in cultivation.

The extension of crop production in this section has been characterized by spurts, following and during cycles of wet years, and

by recession, or at least no increase, during cycles of dry years. During the period 1919 to 1927, the annual rainfall was about 4 inches more than normal, and accordingly crop yields were much above the average. This was also a period of high prices for cotton and to less extent for wheat. During this time the price of cotton was almost twice the average price for the preceding 50 years. Owing to the coincidence of these two more than normally favorable conditions, the production of cotton became extremely profitable and was rapidly extended. The selling price of land rose to \$100 an acre, a value which was in many cases unjustified by the average returns which the land would give. Crop production was extended to include all the good crop soils and a large area of poor or marginal soils which on the whole can be more profitably utilized as pasture. Since 1928 the area of land in cultivation has not increased, and some of the poorer fields have been abandoned.

The present-day agriculture is of two distinct types—crop farming and livestock ranching. In crop farming the farmer's income consists almost exclusively of returns from a cash crop—cotton or wheat; in livestock ranching the rancher's income consists largely of returns from the sale of beef cattle.

In general, crop farming is of a typical one-crop (either wheat or cotton) type. Some farmers produce both wheat and cotton, but on any farm the cash crop is given first call on the farmer's time and energy and is grown on the best soils, and the feed or subsistence crops are more or less incidental. No regular crop rotation is commonly followed, although it is common practice to shift the feed crops from one field to another. Animal manures are not commonly saved, no commercial fertilizers are used, and little is done to build up or maintain soil fertility. Practically no livestock is produced for market on the crop farms. Prior to 1930 the farmers purchased a large part of their home supplies of food, but since that time, owing to low prices for cotton and wheat, the farms have become much more self-sustaining.

The typical cotton farm includes about 160 acres, of which about 100 acres are planted to cotton, between 20 and 40 acres to feed crops, and the remainder is utilized for farm pasture, building sites, and roadways. A farm of this size is worked by the farmer and his family, with extra help employed only for picking cotton and occasionally for chopping cotton. Most of the preparation of the seedbed and other necessary work are done with animal-drawn two-row implements. Mules are more common than horses, and the work animals are hitched abreast in large teams including as many as eight animals. A few tractors are used on the cotton farms.

Following cotton or other row crops, the land commonly is not worked until middle or late winter, as it is largely free of growing weeds at that time and is not greatly benefited by fall preparation. The land is listed late in the winter, either with or without preliminary stalk cutting, and it commonly receives no further preparation prior to planting. The lister planter splits the old bed and places the seed in the new lister furrow. Replantings are frequently necessary, as a crust forms over the soil at times, which prevents emergence of the young plants. The seed is spaced so that individual plants will be from 6 to 18 inches apart in the row without thinning, and less than one-third of the cotton fields are chopped.

The crop is cultivated as soon as possible after the young plants appear. Commonly the crop receives only three or four cultivations, as weeds are comparatively few and easily killed. This is partly because the fields seldom stay too wet for cultivation for any length of time and can be worked at the proper time to most effectively control weed growth. The cultivator shovels are set so as to throw the soil toward the plants and fill up the planter furrows, which results in a deeper rooting of the plants than would otherwise take place.

The land is in general too cold for successful planting of cotton before May 1, and planting is done as soon after that date as possible. Good crops of cotton can generally be obtained from plantings made as late as June 15. Bolls which set by September 1 may reasonably be expected to mature.

Mebane, strains of that variety, and Half-and-Half are the most productive and principal varieties grown.² Early varieties have the greatest possibilities in this section and produce bolls of medium size, with lint not longer than $1\frac{1}{8}$ inch. Varieties in which short lint, earliness, and high gin turn-out are associated, produce higher yields than other varieties. The general area within which Hardeman County occurs is known to the cotton trade as a source of rather low quality cotton, as the staple ranges between seven-eighths and fifteen-sixteenths of an inch and the character of the cotton is rather soft. This is especially true of cotton grown on the shallow and droughty soils, but the moderately sandy soils produce cotton of slightly longer staple and less soft character. Neither the boll weevil nor root rot is present in this county. The average acre yield of cotton over a period of years is about one-third bale, but yields differ widely according to the season and the type of soil.

At least two-thirds of the feed crops grown are grain sorghums. Preparation of the seedbed and culture for these crops are similar to those for cotton. The grain sorghums are commonly planted at any time between the middle of April and the first of June when moisture conditions are favorable. Usually the yields differ little on plantings made at different dates within these limits, but in individual years the yields differ widely. Sorghums will commonly make some grain on plantings made as late as July 1.³ These crops are either headed and the stalks left standing to be pastured, or the whole plants are cut with a row binder and fed in the bundle. Sorghums have a feeding value approximately equal to that of corn. They are very drought resistant, and, although they may produce no grain, they will yield some fodder even during the driest years. Kafir and milo are the principal grain sorghums grown. Smaller acreages are devoted to feterita, hegari, and other varieties. The best varieties of any of these return approximately the same yields of grain.⁴ As milo is frequently damaged severely by chinch bugs, other grain sorghums which are less susceptible, such as kafir, are better adapted to this section. The average acre yield of the grain sorghums over a period of years is about 15 bushels of grain and about 2 tons of air-dried forage. The grain sorghums are occa-

² QUINBY, J. R. VARIETIES OF COTTON FOR THE RED PRAIRIES OF NORTHWEST TEXAS. Tex. Agr. Expt. Sta. Bull. 366, 19 pp., illus. 1927.

³ See KARPEN, R. E., QUINBY, J. R., JONES, D. L., and DICKSON, R. E., footnote 1, p. 4.

⁴ See KARPEN, R. E., QUINBY, J. R., JONES, D. L., and DICKSON, R. E., footnote 1, p. 4. and QUINBY, J. R. footnote 2, above.

sionally sold as a cash crop, either in the bundle to local dairymen or as grain which may be shipped to other sections.

The sorghos are the feed crops of next importance. In this section they will produce more forage than any other crop, and, in addition, during seasonable years will produce some fodder when planted as late as August 1. For this reason, they are utilized as catch crops, especially following small grains. Sumac is the only variety extensively grown, and experimental work indicates that it is the highest yielding variety.⁵

Many cotton farms include a small patch of Sudan grass which is utilized for pasture or hay. It is probably the best cultivated pasture crop available. It is especially valuable during dry spells in the summer, and it furnishes considerably more grazing than good native-grass pasture. A small acreage is devoted to small grains grown for pasture or cut green for hay, and many of the cotton farmers grow some wheat as a cash crop.

As none of the legumes is well adapted to this section, ordinarily none is grown. A few small fields in especially favorable locations are sown to alfalfa which produces fair yields of hay, but alfalfa is not generally adapted to this section and it can be successfully produced only during unusually favorable years or in areas which receive some extra water either through subirrigation or as surface water. Although cowpeas probably are the best adapted annual legume crop, they are grown to very slight extent. They produce an average acre yield between 1 and 1½ tons of air-dried hay.

The comparatively few farms which produce wheat exclusively as a cash crop are, in general, larger than the cotton farms, ranging from 320 to 640 acres in size. Following the wheat harvest in June and July, the land is plowed as soon as possible, generally with a type of disk plow, known as a "one-way plow", which cuts from 2 to 4 inches deep. Further tillage prior to reseeding to wheat consists of reploting with the same implement once or twice, as necessary, in order to kill weeds and volunteer wheat. Most of the winter wheat is seeded between the middle of October and the 1st of December, at a rate ranging from 2 to 4 pecks to the acre. Nearly all the wheat is harvested with a combine. Most of the wheatland is prepared with tractors. Probably not more than one-half of the wheat is produced on the exclusively wheat farms, and the rest is grown on farms which also produce cotton. On such farms the seedbed may be prepared by listing, followed by smoothing down the beds with harrows or disks. The land is more or less rotated to cotton, and the wheat is generally pastured in early spring. The favorite varieties of wheat are hard red winter wheats, such as Turkey, Kanred, Blackhull, and Kharkof. The average acre yield of winter wheat is approximately 12 bushels.

The livestock ranches, which are concerned primarily with the grazing of beef cattle on the native vegetation, occupy about one-fourth of the county. They are confined to the breaks of Pease River and other large areas of land unsuitable for cultivation, and most of them range in size from 2 to 20 square miles. The cattle are high-grade Herefords and are marketed largely as calves and feeder stock. The cattle depend on the native grasses for feed, and about the only supplemental feeding consists of cottonseed cake given when

⁵ VINALL, H. N., GETTY, R. E., and CRON, A. B. SORGHUM EXPERIMENTS ON THE GREAT PLAINS. U. S. Dept. Agr. Bull. 1260, 88 pp., illus. 1924.

necessary during the winter. A few ranchers grow some sorghums which are fed in the bundle during the winter, but this practice is not extensive. The livestock ranches are now confined to sections of the county which probably will always be used for grazing purposes.

According to the 1930 census the county contained 1,388 farms in that year, of which 1,231 were classed as cotton farms, 36 as cash-grain farms, 38 as general farms, 23 as livestock ranches, and the rest as farms of various types. The average size of farms, by types, was as follows: Cotton farms, 198 acres; cash-grain farms, 356 acres; general farms, 160 acres; and livestock ranches, 3,267 acres. Of the 346,965 acres in farms in 1930, 243,832 acres were in cotton farms, 12,827 acres in cash-grain farms, 6,080 acres in general farms, and 75,137 acres in livestock ranches. Although the census reports only 71 percent of the total area in farms in 1930, actually between 85 and 90 percent of the land was utilized for agricultural purposes. The number of farms has increased slightly—to 1,408 on January 1, 1935.

The 1930 census reported 31.1 percent of the farms operated by owners, 68.2 percent by tenants, and 0.7 percent by managers. Most of the owners of the farms live in the nearby towns. The common form of rental is that the landlord receives one-fourth of the cotton and one-third of the other crops. The landlord's share of the wheat crop is commonly one-fourth when the wheat is delivered at the elevator or one-third in the field before harvesting.

According to the 1930 census report the value of all farm property per farm was \$11,870, of which 79 percent was represented by land, 10.6 percent by buildings, 4.3 percent by implements, and 6.1 percent by domestic animals. The average land value, including buildings, was reported as \$42.52 an acre. In 1935 the average value of the land and buildings was much below that figure.

The domestic animals include mules, horses, beef cattle, dairy cattle, chickens, and hogs. The beef cattle are confined largely to the livestock ranches. Few farmers keep more than 2 or 3 milk cows. Most of the hogs raised are killed to furnish meat on the individual farms.

Table 2 shows the acreage devoted to the principal farm crops in this county in 1889, 1899, 1909, 1919, and 1929.

TABLE 2.—*Acreage of principal crops in Hardeman County, Tex., in stated years*

Crop	1889	1899	1909	1919	1929
	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>
Cotton.....	314	1,450	34,686	37,444	114,994
Wheat.....	4,042	7,969	7,059	51,886	24,072
Corn.....	1,617	4,247	23,750	5,677	929
Oats.....	5,662	564	2,479	3,075	165
Sorghums harvested for grain.....			7,156	26,490	23,518
Coarse forage.....		9,648	1,882	6,716	15,837

NATIVE VEGETATION *

With the exception of the very rough and the very sandy sections, Hardeman County and the surrounding country were orig-

* The plants mentioned in this report were identified by V. L. Cory, range botanist, Texas Agricultural Experiment Station.

inally covered with a dense sod of short grasses and much of this growth remains on the virgin soil. Buffalo grass (*Buchloe dactyloides*), which is known throughout western Texas as "mesquite grass", grows in an almost pure stand associated with small amounts of blue grama (*Bouteloua gracilis*), needlegrasses (*Aristida* sp.), snakeweed (locally known as "broomweed") (*Gutierrezia* sp.), and a few other plants. Here and there stunted mesquite trees (*Prosopis* sp.) dot the plain. Buffalo grass is less dominant on the sandy loams than on the clay loams.

The very loose sandy soils are covered with a stunted growth of shin oak brush (*Quercus* sp.) associated with a very thin stand of little bluestem (*Andropogon scoparius*), needlegrasses, sandburs, ragweed, sand sage (*Artemisia filifolia*), wild plum bushes, and many other plants. In areas where shin oak is not present, sand sage is the dominant growth and the grasses are more abundant. The rough land supports a very scant vegetation. Areas of raw droughty clay are covered with a characteristic growth of tobosa grass (*Hilaria mutica*), with some saltgrasses in salty spots. Outcrops of limestone and gypsum within the breaks of Pease River support a shrubby growth of cherrystone juniper (*Juniperus monosperma*), locally known as white cedar, and a very scant growth of grasses and weeds. The bottoms along the larger creeks are covered with a dense sod of buffalo grass and a thicker and heavier growth of mesquite trees than the uplands. Hackberry trees and a few cottonwood trees line the stream channels. The sandy and salty bottoms along Prairie Dog Town Fork Red River and Pease River are covered with saltgrasses, a salt bush (*Baccharis neglecta*), a few cottonwood trees, and a wide variety of herbaceous plants.

Owing to the character of the native vegetation the smooth land of the county had a carrying capacity of from 20 to 30 head of cattle to the section, without supplemental feeding, according to reports of ranchers. Because of heavy grazing and the occurrence of droughty seasons, buffalo grass has practically disappeared from many pastures, needlegrasses and side-oats grama (*Bouteloua curtipendula*) have become much more abundant, and the pastures afford less grazing. During wet winters various annuals, especially wild barley (*Hordeum pusillum*) (locally known as "wild-rye"), plantain (*Plantago* sp.), and a wild flax (*Linum pratense*) make a heavy growth which is attended in most places by a thinning of the buffalo-grass stand. Under favorable rainfall and grazing conditions, the sod of buffalo grass naturally restores itself. In abandoned fields where the buffalo grass has been completely killed out, more than 10 years is required before reestablishment of a good stand of native grasses takes place.

The vegetation on very sandy soils has a somewhat lower carrying capacity than the short-grass vegetation and will carry about 15 or 20 head of cattle to the section. It is affected somewhat less by very droughty conditions. The vegetation on the very rough land, that is in the breaks of Pease River, affords very little grazing and consists largely of grasses growing in the flats along draws.

Two noxious weed pests are widespread in this county—mesquite weed (*Hoffmanseggia jamesii*), which by many people is miscalled "blueweed", and Johnson grass. Both of these, although they grow

principally on the heavy-textured soils, are widely distributed. Mesquite weed, a native plant, spreads slowly but is extremely difficult to eradicate. Fields badly infested with this weed produce materially lower yields and have considerably lower value than fields of similar soils not so infested. The general observation is that mesquite weed reduces yields of wheat to less extent than it reduces yields of cotton or other summer-growing crops. Johnson grass can be killed out in a year or two by clean cultivation, without incurring a great deal of expense. The common field weeds are Russian-thistle, redroot or "careless weed", and a few others, none of which is very troublesome.

SOILS AND CROPS

For purposes of discussion and description and to set forth their value for agricultural use, the soils of Hardeman County may be placed in five groups. Group 1 consists of smooth heavy soils which are excellent for wheat, good for cotton and sorghums, and, with the exception of Randall clay, well adapted to utilization as crop land. This group includes Tillman clay loam, Miles clay loam, Hollister clay loam, Hollister clay, Abilene clay loam, Tipton clay loam, Acme clay loam, Spur clay loam, and Randall clay. These soils cover a total area of 216.1 square miles, or 31.2 percent of the area of the county. Group 2 consists of moderately heavy sandy soils which are excellent for cotton and the sorghums but not so well suited to wheat. This group includes Abilene fine sandy loam, Abilene loam, Abilene loamy fine sand, Abilene fine sand, Miles fine sandy loam, Miles loam, Miles gravelly fine sandy loam, Enterprise very fine sandy loam, Miles loamy fine sand, Enterprise loamy fine sand, and Yahola loamy fine sand. These soils occupy a total area of 120.2 square miles, or 17.5 percent of the county. The soils in these two groups include all the land which is well suited to crop production.

Group 3 includes the very loose sandy soils which produce rather low yields of crops. Their productivity declines after a few years' cultivation, and the cultivated areas should be planted to sorghums or some crop which reduces soil blowing. In addition to the cultivable areas, these very sandy soils include a considerable acreage of soils which are so loose that they are entirely unsuitable for the production of crops. This group includes Miles fine sand; Enterprise fine sand; Enterprise fine sand, dune phase; and Yahola fine sand. These soils cover a total area of 81.1 square miles, or 11.7 percent of the county. Group 4 includes sloping shallow soils which are marginal for wheat. They can be cultivated and to some extent they are, but crop yields are low and most of such land should be used for grazing. The soils of this group are Vernon clay loam, Weymouth clay loam, Weymouth very fine sandy loam, and Acme clay loam, shallow phase. These soils cover a total area of 87.5 square miles, or 12.5 percent of the county. The land included in group 5 consists of rough or stony land which has no agricultural value other than for grazing. The types of land in this group are rough broken land; Vernon clay, eroded phase; Miller clay, colluvial phase; Weymouth stony loam; and river wash. These cover a total area of 188.1 square miles, or 27.1 percent of the county.

Each of the main soil groups is dominant in certain sections, giving rise to general soil areas which are outlined in figure 2.

Nearly one-half of the land is well suited for crop production, one-fourth is normally marginal land, and slightly more than one-fourth is land entirely unsuitable for cultivation. According to the census, approximately 190,000 acres, or 297 square miles, were in crops in 1929, and the area in cultivation has not materially changed since that time. It is estimated that the 297 square miles of crop land were distributed approximately as follows: 185 square miles of smooth heavy soils in crops, 75 square miles of moderately sandy soils in crops, 20 square miles of very sandy soils in crops, and 20 square miles of shallow soils in crops.

About 60 percent of the crop land in 1929 was in cotton, 15 percent in wheat, 20 percent in grain sorghums, and the rest in various other crops, of which sorgo, corn, and Sudan grass were the most important. The ratios between the amount of land devoted to crops, especially that between the two cash crops—cotton and wheat—differ from year to year, depending on the relationship between the prices of the two crops and, to less extent, on moisture conditions at planting time. Most of the wheat is grown on the smooth heavy soils; more cotton is grown on the moderately heavy sandy soils than on the soils of any other group; and the feed crops—grain sorghums, sorgos, and corn—occupy a larger proportion of the land in crops on the very loose sandy soils than on those of any other group. The shallow soils in cultivation are devoted largely to wheat.

Group 1, the group of smooth heavy soils, is the most extensive and includes about two-thirds of all the land well suited to crop production. Because of the extensive occurrence of the soils of this group, Hardeman County is a potential, and during some years an actual, producer of large quantities of wheat. These soils are rich, smooth, resistant to blowing, and have a large water-holding capacity. They are well suited to small grains, and, in fact, the friable and granular members of the group constitute ideal soils for wheat in this climatic section. They are also good soils for the production of cotton and grain sorghums, but, owing to their heavy texture, they are not sufficiently drought resistant to be ideal for these crops.

Throughout the southern Great Plains region the soils which give the highest average yields of wheat are invariably heavy in texture—generally clay loams—whereas the soils which give the highest yields of cotton and grain sorghums are moderately sandy—generally fine sandy loams. The clay loams produce about one-half more wheat than do the fine sandy loams and only about two-thirds as much cotton or grain sorghums. These ratios are a rough estimate based on observation only, there being, so far as the writer knows, no exact data.

Soil blowing is one of the factors which causes the greater suitability of the heavy soils for small grains, but this is of comparatively little importance on soils as heavy as fine sandy loam. Furthermore, the higher yield of wheat on the clay loams than on the fine sandy loams during years when no soil blowing has occurred on either shows that some other fundamental cause is operative. The clay loams give higher yields of wheat than do the fine sandy loams, during both wet and dry years. Considered on a cropping basis, the principal differences between the heavy soils and the soils of

medium texture are that the heavy soils contain a greater total supply of plant nutrients which presumably become available somewhat more slowly, they have a greater water-holding capacity, they absorb water more slowly and accordingly lose more through runoff and evaporation, and, especially in the more compact types, the deeper soil layers of the heavy soils are penetrated by plant roots more slowly and less thoroughly. Because during wet years the clay loams give higher yields of cotton and grain sorghums than do comparable fine sandy loams, it seems probable that the lower average yield is due to moisture relationships and is caused largely by the greater loss of water through evaporation and run-off.

An excavation in a soil reveals a series of layers, or horizons, known collectively as the soil profile. The character of the profile, together with such general features as drainage, relief, and stoniness, determine how the soil is classified. The characteristics and properties of the soil are those that can be determined by simple tests in the field. The three units used in field mapping of soils are series, type, and phase. Most important of these is the series which includes soil types having essentially the same color, structure, thickness of the several horizons, relief, and drainage, and approximately the same parent material. The series are given geographic names taken from the location in which the included soils were first recognized. The types within the series are named according to the texture of the surface soil, as sand, sandy loam, or clay. The textural class name added to the series name gives the complete name of the type. A phase is a subdivision of a type, having characteristics worthy of recognition, yet not sufficiently different from the typical soil to justify the establishment of a new type. For example, in this county, Enterprise is the name of a series, Enterprise fine sand the name of a type, and Enterprise fine sand, dune phase, the name of a phase, or slight variation from the type.

In the following pages the soils of Hardeman County are described in detail, and their agricultural relationships are discussed; their location and distribution are shown on the accompanying soil map; and their acreage and proportionate extent are given in table 3.

TABLE 3.—*Acreage and proportionate extent of soils mapped in Hardeman County, Tex.*

Type of soil	Acre	Per- cent	Type of soil	Acre	Per- cent
Tillman clay loam.....	51,200	11.5	Enterprise loamy fine sand.....	16,576	3.7
Miles clay loam.....	25,856	5.8	Yahola loamy fine sand.....	1,664	.4
Hollister clay loam.....	32,128	7.2	Miles fine sand.....	14,528	3.3
Hollister clay.....	6,976	1.6	Enterprise fine sand.....	21,824	4.9
Abilene clay loam.....	7,744	1.8	Enterprise fine sand, dune phase.....	13,760	3.1
Tipton clay loam.....	7,744	1.8	Yahola fine sand.....	1,792	.4
Acme clay loam.....	2,432	.5	Vernon clay loam.....	30,336	6.8
Spur clay loam.....	3,968	.9	Weymouth clay loam.....	20,992	4.7
Randall clay.....	256	.1	Weymouth very fine sandy loam.....	1,920	.4
Abilene fine sandy loam.....	12,032	2.7	Acme clay loam, shallow phase.....	2,752	.6
Abilene loam.....	6,976	1.6	Rough broken land.....	56,896	12.8
Abilene loamy fine sand.....	4,864	1.1	Vernon clay, eroded phase.....	22,720	5.1
Abilene fine sand.....	1,280	.3	Miller clay, colluvial phase.....	4,288	1.0
Miles clay loam.....	13,632	3.1	Weymouth stony loam.....	30,528	6.9
Miles loam.....	4,800	1.1	River wash.....	5,952	1.3
Miles gravelly fine sandy loam.....	1,664	.4			
Enterprise very fine sandy loam.....	2,112	.5			
Miles loamy fine sand.....	11,328	2.6	Total.....	443,520	

SMOOTH HEAVY SOILS

The smooth heavy soils are the leading soils for wheat in this county. Although on most farms a larger proportion of them is utilized for cotton than for wheat, most of the wheat produced is grown on these soils. Although the smooth heavy soils are somewhat better soils for wheat than for cotton, owing to the prices that have prevailed for the two crops during the last few years, greater returns per acre have been obtained on these soils from cotton than from wheat. Cotton is a higher priced crop than wheat, and within the climatic section where both can be grown successfully, cotton can displace wheat even on land which is naturally better adapted to wheat than to cotton.

Approximately three-fourths of the total area of the smooth heavy soils is utilized as crop land, and the part remaining in sod consists largely of small irregular areas surrounded by less valuable soils. About four-fifths of the land in cultivation is planted to a cash crop—either cotton or wheat. The ratio between these two cash crops differs widely from year to year, although cotton is generally dominant, and it is determined by the relative prices of the two crops and weather conditions at planting time. Harvesting of wheat is done largely with combine harvesters which are hired, and neither this crop nor cotton requires a large investment in special equipment by the farmer; therefore, the farmers are able to change from one crop to the other comparatively quickly and with little expense. In the more recent census years the ratios between the acreage in cotton and the acreage in wheat on these smooth heavy soils have been about as follows: In 1919, 4 acres in cotton to 5 in wheat; in 1924, 3 acres in cotton to 2 in wheat; and in 1929, 3 acres in cotton to 1 in wheat. The trend toward the production of more cotton has reversed since 1929, and in 1932 the ratio between the two crops approached that of 1924. The remaining one-fifth of the cultivated part of these soils is devoted to feed or subsistence crops, principally grain sorghums.

These smooth heavy soils are held for the most part in crop farms which produce cotton primarily, with some wheat as a secondary cash crop and enough grain sorghums or other feed crops for the work animals. Mules or horses are used on most of the farms, and on a number of the strictly wheat farms tractors are used. A few of the tractor-equipped wheat farms are west of Chillicothe, but most of them are in the general vicinity of Goodlett. The strictly wheat farms commonly are located on some of the less productive soils, and they are large, most of them including a half section or more of land.

The smooth, heavy soils occupy two main sections—the Quanah plain and the western two-thirds of the Chillicothe plain. The Quanah plain is dominantly a broad area including two smooth distinctly red soils—Tillman clay loam and Miles clay loam. Both have dark reddish-brown surface soils and are commonly known as "red tight land." The broad area of these two soils is broken and dotted with slopes and knolls, occupied by shallow or stony soils—the Vernon and the Weymouth. As these shallow soils constitute one-fourth or more of the total extent of this plain they materially lessen the agricultural value of the land. The Chillicothe plain is smooth and flatter than the Quanah plain, and it

embraces practically no shallow soils. The soils are darker colored than those on the Quanah plain and are somewhat less compact or tight. The Chillicothe plain is a much better farming section than the Quanah plain, wheat is a less important crop than on the Quanah plain, and the selling price of land is almost twice as high. This plain includes a broad area of Hollister clay loam and Hollister clay, both of which are commonly called "black land."

The average acre yield of wheat on the smooth heavy soils is between 12 and 15 bushels, and the average acre yield of cotton over a period of years is between one-fourth and one-third bale. During extremely favorable years the average acre yield of cotton may be one-half bale and of wheat 25 bushels, but in unfavorable years the crops are total failures. Maximum yields of more than 50 bushels of wheat an acre and $1\frac{1}{4}$ bales of cotton have been obtained. The range in productivity between the soils in this group is not great. Other factors being equal, the more granular and friable soils are more productive than the compact and tight soils; and the darker colored soils are more productive than the reddish-colored soils. Under good farm management, in order of productivity the soils of this group rank as follows: (1) Abilene clay loam, Tipton clay loam, Acme clay loam, and Spur clay loam, with average acre yields of 200 to 250 pounds of lint cotton, 25 bushels of threshed grain sorghums, or 18 bushels of wheat; (2) Hollister clay loam and Hollister clay, with average acre yields of 165 pounds of lint cotton, 20 bushels of threshed grain sorghums, or 15 to 18 bushels of wheat; (3) Tillman clay loam and Miles clay loam, with average acre yields of 125 pounds of lint cotton, 15 bushels of threshed grain sorghums, or 12 to 15 bushels of wheat; and (4) Randall clay which is not cultivated, owing to poor drainage. This ranking is based largely on soil characteristics rather than observed crop yields, although it is supported by farmers' observations and by land valuations of the different soils in different communities. The differences in yields are much more pronounced in cotton than in wheat.

The soils of the first and second classes, especially where they are developed in large uniform areas, have the highest sales values of the soils in this county. These soils are no more productive than the moderately heavy sandy soils which in general have a somewhat lower selling price.

Tillman clay loam.—Tillman clay loam is a dark reddish-brown deep rather compact soil. Locally this soil, together with several others, is commonly known as "red tight land", but of the several soils thus named Tillman clay loam occupies the smoother and better land. Typical smooth flat areas occur near Quanah and Goodlett. This is a good moderately productive soil, but it is somewhat tight and droughty.

In virgin areas the topsoil consists of a 1- or 2-inch surface layer of dark-brown friable clay loam underlain, to a depth of 10 or 12 inches, by dark reddish-brown friable granular clay. With increase in depth the soil gradually becomes more compact and less dark. Below a depth of 12 inches the soil material is reddish-brown tight compact clay which extends to a depth of about 24 inches where it grades into brownish-red or red calcareous compact tight clay. This material becomes more highly calcareous with increase in depth, and, at a depth ranging from 36 to 42 inches, grades into red compact

highly calcareous clay with a content ranging from 5 to 10 percent of soft and hard almost white irregular lumps or concretions of calcium carbonate. Below this the whitish concretions are less abundant, and are completely absent at a depth of about 10 feet below the surface where the substratum consists of slightly calcareous compact red shaly clay. The soil material above a depth of about 24 inches is not calcareous.

In areas where this soil has been cultivated it is heavy clay loam through the plow depth. The cultivated soil is friable, is not very difficult to till, and, when in the proper moisture condition, works down to an excellent seedbed. During the warm season it is commonly ready for cultivation within a day or two following a good rain and remains sufficiently moist for a week or more. No harm is done by breaking the soil when very dry, and it does not puddle badly when wet, as the clods which are formed generally crumble with the next two or three rains.

A few areas are included in mapping, in which the friable material on the surface is thinner and the granular structure is less well developed than in areas of the typical soil. The degree of darkness of the soil also varies considerably, ranging between the darker limit where this soil merges with Hollister clay loam and the redder and shallower limit where it adjoins Vernon clay loam.

This is an extensive soil and constitutes the dominant smooth soil throughout the western two-thirds of the county. It is a good soil for wheat and a fairly good soil for cotton and the grain sorghums. Most of it occurs as rather smooth irregular areas associated with some shallow and less productive soils, hence the general section of its occurrence is one of rather poor soils on which cotton is not very successful. Thus, wheat production is dominant and a relatively large proportion of the land within this part of the county is devoted to wheat. Wherever a farm includes a mixture of this soil and shallower soils, so far as is practical cotton is planted on Tillman clay loam and wheat on the poorer soils.

Miles clay loam.—Miles clay loam is the other reddish-colored soil of this group. It differs from Tillman clay loam in that it is more granular and friable and much less compact or tight. It occurs as gently sloping areas, and it is moderately productive.

In undisturbed grassland, the 1- or 2-inch surface layer consists of dark-brown friable platy silt loam, and it is underlain by dark reddish-brown friable granular clay. Below a depth of 12 inches, the material is less dark and consists of reddish-brown friable granular clay to a depth of about 24 inches, where it grades into light reddish-brown or brownish-red friable clay. At a depth ranging from 30 to 36 inches, the deeper soil material grades into a whitish-colored layer consisting of a mixture of light reddish-brown highly calcareous friable clay, and from 25 to 75 percent of soft whitish lumps and layers of carbonate of lime. This layer, the zone of carbonate concentration, is called "gyp" by many farmers, but, so far as could be judged by field examination, it contains little or no gypsum. It grades downward into either less highly calcareous friable dull-red clay or into a thin ledge of partly weathered limestone bedrock.

In most places all the soil layers are calcareous, although the upper layers are much less so than the lower ones. In the smoother and deeper areas of this soil the surface soil may contain no free carbonates to a depth of a foot or more. Small irregular hard whitish concretions of calcium carbonate are thinly scattered over the surface and throughout the soil layers. These are less hard where more deeply buried, and fine white threads and films of carbonate of lime are present along old rootlet channels and crevices in the soil below a depth of 2 feet. The soil material to a depth of 2 feet breaks into large vertical prisms, ranging from 3 to 6 inches in diameter, which crumble readily to somewhat rounded pellets or granules about one-eighth of an inch in diameter. Below a depth of 2 feet the material is friable but not granular and breaks into massive clods which can be readily crushed between the fingers. Worm casts are abundant throughout all soil layers. The color of the soil along a broken surface is considerably darker than that of the crushed material, as the outsides of the granules are coated with a film of very dark dull-brown material which apparently is organic matter.

This is one of the extensive soils of the county. It occupies no large broad areas but occurs widely scattered throughout the western two-thirds. Characteristically it occurs as smooth areas surrounding and intermixed with outcrops of limestone bedrock. The areas underlain by limestone have a nearly white carbonate zone which contains very little earthy material. The principal areas of this character occur on the low tableland a few miles northeast of Herg and a few miles northwest of Quanah. An included variation, which occurs on colluviallike lower slopes, has a less definite carbonate zone that is much less white, contains 75 percent or more of fine-earth material, and is underlain at a depth ranging from 3 to 4 feet by red shaly compact clay. This variation from the typical soil is slightly less productive. The most extensive areas occupy the lower slopes surrounding the high land at and extending west of Herg, and smaller bodies lie east of Lazare and in a few other localities.

After plowing, the surface soil of Miles clay loam, to plow depth, is very friable clay loam which can be worked throughout a wide range of moisture conditions, forms an excellent seedbed, and does not crust badly. This soil absorbs water readily, and it is comparatively drought resistant, especially where terraced. The range in slope is from about 1 to 3 percent, and, owing to its greater slope, this soil is somewhat shallower and less fertile than the more nearly level soils; but it is approximately one-fourth more productive for wheat than the tighter Tillman clay loam, the difference in yields being most pronounced during dry years. It would seem probable that a like relationship in yields holds for cotton and sorghums, as, normally, in this section these crops respond better to drought-resistant soils than does wheat, but contrary to expectation, farmers report that the yields of cotton and grain sorghums on the two soils are approximately the same.

This soil is commonly called "red land", and the difference between it and Tillman clay loam, although noticed by many farmers, is not a striking characteristic which can be readily observed, and it commonly is not recognized. To the casual observer, this soil, owing

to its generally less favorable surface relief, seems to be less valuable than Tillman clay loam. The selling price of the two soils is approximately the same.

Hollister clay loam.—Hollister clay loam is one of the two extensive dark-colored heavy soils which occupy the flat plain west of Chillicothe. It is known locally, together with several other dark-colored soils of heavy texture, as "black land." It is a productive smooth well-drained moderately friable clay loam with a compact black clay subsoil. This soil differs from Tillman clay loam primarily in its darker color. It occupies more nearly level areas and is more productive.

In undisturbed grassland, the 1- or 2-inch surface layer consists of very dark grayish-brown friable platy clay loam. This is underlain, to a depth of about 10 inches, by nearly black moderately granular and friable clay. This clay breaks naturally into large clods which, when extremely dry, crumble to subangular pellets about one-eighth of an inch in diameter. Below a depth of 10 or 12 inches the clay is very compact and tight and breaks apart into large clods which have slick and shiny surfaces. This material is very hard when dry and very plastic and sticky when wet. The clay texture and the very compact and hard cloddy structure continue downward without material change throughout the rest of the soil profile. The dark color gradually decreases from nearly black in the topmost 12 inches of soil, through very dark brown, between depths of 12 and 24 inches, and brown, below a depth of 24 inches, to the calcium carbonate zone which lies at a depth ranging from $3\frac{1}{2}$ to 4 feet. The material in this zone consists of brown or light-brown very compact highly calcareous clay spotted with soft white lumps of carbonate of lime which range from mere specks to pellets one-half inch in diameter. The highly calcareous zone is several feet thick, and the lumps of carbonate of lime become larger and much less numerous with increase in depth. The brown color and a few scattered concretions persist downward to a depth ranging from 10 to 12 feet, where the material slowly grades into deep-red slightly calcareous compact raw clay—the parent material. Typically the soil material is calcareous below a depth ranging from 12 to 24 inches but not above that depth.

In cultivated fields the topsoil, or the part that has been mixed by cultivation, is moderately friable heavy clay loam. This soil has tillage characteristics similar to those of Tillman clay loam. Following heavy downpours of rain, a crust is formed which prevents emergence of newly planted crops unless the crust is broken by a very light cultivation. The land dries out rather slowly following heavy rains and remains in a favorable condition for cultivation for several weeks. When in the proper moisture condition it works down to an excellent seedbed. When extremely dry the soil material shrinks, cracks 1 or 2 inches wide and several feet deep are formed, and the thin surface layer crumbles to fine grains. Even in cultivated fields this soil seldom becomes moist below a depth of $2\frac{1}{2}$ or 3 feet.

This is a very good soil which produces excellent crops of wheat and fairly good crops of cotton and grain sorghums. Because a moderate yield of cotton is normally more profitable than an excellent crop of wheat, most of the land is planted to cotton and only small acreages to other crops.

This soil occurs as a broad flat uniform area on the Chillicothe plain and as smaller nearly level areas in other localities. The selling price and assessed value for taxation purposes are as high as for any soil in the county.

Hollister clay.—Hollister clay is a heavier, tighter, and more compact soil than Hollister clay loam but is otherwise similar to that soil. It is locally known as "black land." It consists of nearly black clay which is moderately compact in the surface layer and very compact in the lower layers.

In virgin grassland areas the surface soil consists of a $\frac{1}{2}$ - or 1-inch layer of platy clay loam underlain by moderately friable very dark brown or nearly black clay which, when very dry, breaks into irregular clods that crumble to small angular or subangular fragments. Below a depth of 5 or 6 inches the soil material is very compact dark yellowish-brown or dark-gray clay which, for the most part, breaks vertically into irregular very hard clods with slick and shiny surfaces. When dry, the material is very hard and cannot be spaded unless it is loosened with a pick or a bar, and when wet it is very sticky. This clay continues downward without change in texture, structure, or consistence, but the color gradually becomes less dark. Below a depth ranging from 10 to 20 inches the color is yellowish brown and continues so to a depth of about 40 inches where the material grades into light-brown very compact clay spotted with whitish lumps of soft carbonate of lime. This highly calcareous layer is about 2 feet thick and grades downward into less highly calcareous very compact clay. In most places the soil is calcareous at all depths, although local spots contain no free lime to a depth ranging from 6 to 12 inches. No part of the soil contains worm casts.

Where the land is cultivated, the thin surface veneer of clay loam has been mixed with a 3- or 4-inch layer of the underlying clay, and the resultant plowed topsoil is light clay. According to farmers, it is somewhat easier to obtain stands of crops on this soil than on Hollister clay loam, as the crust, which forms following rains, on further drying checks and cracks into fine grains and commonly does not prevent emergence of the germinating plants. This is a good soil, but its characteristics indicate that it is slightly more droughty and less productive than Hollister clay loam.

Abilene clay loam.—Abilene clay loam is a very friable and crumbly nearly black soil. It differs from Hollister clay loam in that it is less compact or tight, especially in the lower soil layers. It is an excellent soil, as it is drought resistant, very fertile, and productive.

In areas of undisturbed sod, the surface soil consists of a 2-inch layer of dark-brown friable platy silt loam underlain by very friable and granular very dark brown or nearly black clay which extends to a depth of about 24 inches. The color gradually becomes lighter with depth, and below a depth of 12 inches it is dark brown. Below a depth of 24 inches the soil material consists of friable brown or grayish-brown calcareous clay which at a depth of about 36 inches grades into a lighter colored or almost white layer. The light-colored layer consists of grayish-brown friable highly calcareous clay containing numerous soft or semihard spots or concretions of carbonate of lime. This highly calcareous layer is several feet thick and grades downward into less highly calcareous clay. Typically

the 18- or 24-inch surface soil contains no free carbonate of lime, but below that depth the soil becomes increasingly calcareous down to the light-colored layer.

The cultivated surface soil is friable clay loam to plow depth. The soil works readily and has tillage characteristics similar to those of Hollister clay loam, but it is slightly less tight and does not crust so badly.

This soil occupies rather small flat areas and is not extensive. The largest body is in the vicinity of Big Valley School, where it constitutes a marginal belt between higher sandy land to the east and a large flat of Hollister clay loam to the west. A small but typical area occurs on a high flat about one-half mile west of Herg. Practically all of this soil is in cultivation, and nearly all of the cultivated land is devoted to cotton.

Tipton clay loam.—Tipton clay loam occupies low flats along North Groesbeck and Wanderers Creeks. These flats are high bottoms which are very seldom overflowed. Most of the areas have been flooded only 3 or 4 times during the 60 years since this section of Texas was first settled. This soil is similar to Abilene clay loam and, so far as has been observed, the two soils produce similar yields of the field crops commonly grown.

The topsoil of Tipton clay loam is very friable crumbly granular calcareous very dark brown clay loam or clay, which extends downward without change to a depth of about 18 inches, where it grades below into dark-brown calcareous granular friable clay loam or clay. Below a depth of about 30 inches the granular structure disappears, the soil material is highly calcareous, and numerous white threads and films of carbonate of lime occur throughout the soil mass. This material continues downward to a depth ranging from 10 to 20 feet without change other than to become slightly less dark.

This is an excellent soil, and most of it is utilized for the production of cotton. Owing largely to its occurrence in small areas adjacent to deep stream channels and in part to the heavier original growth of mesquite trees which involved considerable clearing before the soil could be cultivated, only about 60 percent of the land is in cultivation. Nearly all of the alfalfa grown in the county is grown on this soil. The successful production of alfalfa without irrigation in this section is confined to spots and local areas where the water table lies at a depth of less than 20 feet or to low places where water collects following rains, as alfalfa requires more water than is normally supplied by the rainfall. In areas of Tipton clay loam adjacent to permanent streams the water table in most places lies at approximately the same level as the water in the stream or at a depth ranging from 10 to 20 feet below the surface. On such areas alfalfa produces from 2 to 4 tons of hay an acre during normal years, and a fair stand will live through the driest years. On probably one-half of the total area of this soil alfalfa can be grown with fair success. It is possible that pecans also will grow if the trees get a good start, as pecans were reported by the early settlers as native in this section along the main streams about as far west as Chillicothe.

Acme clay loam.—Acme clay loam is the very friable and granular nearly black deep soil underlain by gypsum. It is an excellent

soil and, so far as could be observed, it is similar to Abilene clay loam in productivity, drought resistance, and other agricultural characteristics.

In virgin areas the surface soil consists of a 1- or 2-inch layer of calcareous very dark brown friable platy clay loam or silt loam underlain by calcareous very friable crumbly and granular nearly black clay. On drying, this material crumbles readily to granules which are about one-eighth of an inch in diameter, somewhat rounded, dull black on the outsides, and dark brown in the interiors. With increase in depth the color becomes less dark, and at a depth of about 20 inches the material is dark-brown friable massive cloddy clay. At a depth ranging from 30 to 40 inches the soil material is abruptly underlain by glistening white nearly pure gypsum. Worm casts are abundant throughout the soil mass, and all parts are readily permeated by water and plant roots. White threads of gypsum and lime are present in the 6- to 10-inch layer of soil material immediately overlying the gypsum. The thickness of the soil over the gypsum is extremely variable, and included in mapping are small spots of Acme clay loam, shallow phase, most of which are not more than 100 feet in diameter. These shallow spots are droughty and much less productive than the typical soil.

This is an inextensive soil and occupies flat areas. The principal bodies are in the vicinities of Acme and Lake Pauline. Although highly productive and an excellent soil, owing to the fact that it is surrounded by unproductive soils, not more than one-third of the total area is in cultivation. Where cultivated, cotton, the principal crop, returns good yields.

Spur clay loam.—Spur clay loam is a dark reddish-brown calcareous clay loam soil subject to overflow. It consists of recently deposited stream sediments, or alluvium, whose character depends on the soils drained by the streams along which the Spur soil occurs. Areas, such as those in the breaks of Pease River, which lie adjacent to streams heading in rough broken land or areas of Vernon soils, are compact, infertile, distinctly tinged with red, and would be droughty and unproductive if cultivated. Bodies along draws draining areas of smoother and deeper soils are darker, richer, more friable, and are capable of becoming very productive crop land. Owing to its occurrence in areas cut by meandering stream channels most of this soil is utilized as grazing land.

The bodies along the lower course of Groesbeck Creek are of loam texture. Four areas mapped as this soil in the Pease River bottom east of the highway bridge are in reality Yahola clay which consists of brownish-red calcareous clay underlain at a depth ranging from 1 to 2 feet by reddish-yellow fine sand.

Randall clay.—Randall clay is the soil which occupies the intermittent lakes, or "gyp sinks", within the county. It consists of dark-gray noneffervescing extremely compact clay which becomes less dark with depth. Below a depth of about 24 inches it is gray calcareous extremely compact clay which grades into yellowish-gray calcareous extremely compact clay at a depth of about 48 inches.

This soil occurs in small areas on the plain west of Quanah. It is poorly drained, and the land is occasionally covered with water for

several weeks at a time. The color of the soil in some of the smaller and less poorly drained bodies is nearly black. No outlets can be provided to drain most of the areas, although proper terracing of the surrounding land would to a great extent prevent accumulation of excess water. As the soil itself is an extremely compact clay, it is droughty, but, owing to the fact that it receives water as run-off from higher country during certain seasons it might produce good yields of crops. In general it is not suitable for crop land, and at present none of it is in cultivation. Even if properly drained it might not be a very productive soil.

MODERATELY HEAVY SANDY SOILS

The moderately heavy sandy soils are the best cotton soils in Hardeman County and the surrounding country. They constitute about one-sixth of the total area of the county, but, owing to their highly suited characteristics for farm crops, they are agriculturally very important and include about one-third of all the land in cultivation. About 80 percent of the soils of this group is in cultivation, and practically none of the arable land remains untilled. At least three-fourths of the land in cultivation is planted to the cash crop—cotton—and the rest to feed or subsistence crops consisting primarily of grain sorghums and sorgos. Small acreages are devoted to Sudan grass, corn, and small grains.

These soils are productive, drought resistant, and moderately fertile. They are better soils for cotton and the grain sorghums than they are for small grains. The average acre yield of cotton is between one-third and one-half bale, and the average acre yield of grain sorghums over a period of years is between 15 and 20 bushels of threshed grain.

Although these soils have the highest producing capacity of any in this county, their selling price has never reached so high a figure as did that of the large smooth areas of Hollister clay loam on the Chillicothe plain.

According to productivity the soils of this group rank as follows: (1) Abilene fine sandy loam, Abilene loam, and Abilene loamy fine sand, with average acre yields of 250 pounds of lint cotton or 25 bushels of grain sorghums; (2) Miles fine sandy loam, Miles loam, Miles gravelly fine sandy loam, Enterprise very fine sandy loam, and Abilene fine sand, with average acre yields of 165 pounds of lint cotton or 20 bushels of grain sorghums; and (3) Miles loamy fine sand, Enterprise loamy fine sand, and Yahola loamy fine sand, with acre yields ranging from 75 to 125 pounds of lint cotton or 15 bushels of grain sorghums.

Abilene fine sandy loam.—Abilene fine sandy loam is a dark smooth moderately heavy sandy soil. It occurs in the vicinities of Farmers Valley, Center Point School, and Big Valley School, and in a few other localities. It is locally known as "black sandy land" and is one of the best and most productive soils in the county.

The topsoil consists of dark-brown or very dark brown friable and granular fine sandy loam. Below a depth of 8 or 10 inches this material grades into dark-brown friable granular loam. The granular structure disappears and the color is brown at a depth ranging from 24 to 30 inches, and the soil material below that depth is brown friable massive and cloddy loam. Below a depth

of about 4 feet the material is slightly calcareous reddish-yellow friable fine sandy loam with thick white films of carbonate of lime coating the vertical crevices in the soil. The soil contains no free carbonate of lime to a depth of about 4 feet.

Although this soil is not very extensive, it is important agriculturally and is widely known for its excellent character and good crop yields. It occupies nearly level well-drained flats. The soil is easy to work, crusts very little, and works into an excellent seed-bed. Where well farmed the average acre yield over a period of years is about one-half bale of cotton and 25 bushels of threshed grain sorghums. On some fields maximum yields of $1\frac{1}{2}$ bales of cotton and 60 bushels of threshed grain sorghum have been reported during favorable years.

Abilene loam.—Abilene loam is very similar to Abilene fine sandy loam and it occurs in the same general localities. It occupies smooth, nearly level, well-drained areas. It is locally known as "black loam." It is very productive and is slightly richer but not quite so drought resistant as Abilene fine sandy loam. It is an equally good soil for cotton and feed crops and slightly better for small grains.

The 7-inch surface layer of this soil consists of very dark brown friable granular loam which grades downward into dark-brown friable and granular clay loam. Below a depth of 24 or 28 inches, this material, in turn, grades into brown or dull reddish-brown friable massive cloddy loam. At a depth of about 4 feet this material grades into calcareous yellowish-red loam containing white films and streaks of carbonate of lime along crevices in the soil and old root channels. This soil contains no free carbonate of lime above a depth of about 4 feet. It is friable and easily penetrated by moisture and plant roots.

Abilene loamy fine sand.—Abilene loamy fine sand is similar to Abilene fine sandy loam, from which it differs primarily in that it is more sandy throughout both topsoil and subsoil. It is an excellent soil and very productive. It occurs as flat areas along the bases of the high broad ridges of very sandy soils. Nearly all the land is in cultivation, and a very large proportion of the cultivated land is devoted to cotton.

To a depth of about 24 inches this soil consists of very dark brown mellow loamy fine sand which at this depth grades into dark-brown friable fine sandy loam. Below a depth of about 36 inches the material is brown light fine sandy loam which grades into reddish-yellow loamy fine sand at a depth of about 6 feet. The soil material above a depth of about 6 feet contains no free carbonate of lime, but below that depth it is faintly calcareous and white films coat the vertical crevices in the soil. In places where the land has been in cultivation for 20 years or more the plowed topsoil is brown and distinctly less dark than the material below.

This soil is sufficiently sandy that careful management is required to prevent soil blowing. It is highly productive but not so strong as some of the heavier textured soils. Although no marked decrease in yields has taken place, a rather rapid decrease in fertility following cultivation is clearly indicated by the marked decrease in the dark color of the surface soil. Several areas of this soil are naturally subirrigated and have the water table sufficiently close to the surface that the roots of the common crops can draw from it as a

source of moisture. The soil in the subirrigated areas is darker than in similar areas where the water table lies at a greater depth. This extra supply of water largely accounts for the darker than normal color for a soil of this texture. This soil occurs in small areas, the largest of which are in the Farmers Valley, Center Point School, and Bailey School sections.

Abilene fine sand.—Abilene fine sand is similar to but more sandy than Abilene loamy fine sand. It is locally known as "black sand." It occurs only in small areas which are naturally subirrigated and also receive some run-off water from surrounding higher areas.

In virgin areas the 18-inch topsoil consists of dark-brown or very dark brown fine sand. This grades downward into brown loamy fine sand which extends to a depth ranging from 4 to 5 feet, where it grades into reddish-yellow fine sand. In most places the soil contains no free carbonate of lime above a depth of 5 feet, but in most of the subirrigated spots white concretions of carbonate of lime are present at the base of the water-bearing strata, and black iron concretions occur at somewhat higher levels.

Abilene fine sand, largely owing to its occurrence in subirrigated areas or low spots where water collects following rains, is a highly productive soil for cotton and feed crops. It is too sandy to be a typical member of the group of moderately heavy sandy soils, but because of its high productivity it is included within that group. It is subject to some soil blowing unless carefully managed, but, owing to its occurrence in sheltered positions, this is not serious. Fields which have been cultivated for several years are much less dark and blow more readily than does the freshly broken land. It seems evident that continued cultivation to cotton will cause rapid loss of organic matter and make the soil so loose that much of it will have to be planted to grain sorghums in the future. At present this soil is utilized very largely for growing cotton which produces an average acre yield of about one-half bale.

Miles fine sandy loam.—Miles fine sandy loam is locally known as "red sandy land." It is similar to, but more rolling, less dark colored, redder, and less productive than Abilene fine sandy loam. It is a good drought-resistant soil, well adapted to the production of cotton and grain sorghums.

The topsoil is dark reddish-brown friable granular fine sandy loam ranging from 10 to 14 inches in thickness. It grades downward into reddish-brown friable and granular loam or fine sandy clay loam. At a depth ranging from 24 to 28 inches the granular structure disappears, the color becomes redder, and the lower part of the subsoil consists of yellowish-red friable massive loam. At a depth ranging from 5 to 7 feet this material grades into yellow highly calcareous fine sandy loam containing numerous white films and soft lumps of carbonate of lime. At a greater depth the lime content decreases, and in many places the deep substrata contain some water-worn gravel. The soil material contains no free carbonate of lime to a depth within a few inches of the highly calcareous layer.

A variation from the typical soil is included in mapping, in which the underlying material, at a depth ranging from 3 to 8 feet, consists of weakly bound red sandstone. The soil in such areas is much brighter red and the texture of the surface soil in most places is very

fine sandy loam. The areas mapped as Miles fine sandy loam, which occur within a few miles north and west of Big Valley School and in the vicinity of Star Valley School, and a part of the areas near Center Point School, consist of this included soil.

Miles fine sandy loam is one of the more extensive moderately heavy sandy soils. At least 80 percent of the total area is in cultivation, and a large proportion of the cultivated land is devoted to cotton. This soil is very drought resistant, moderately fertile, and moderately productive. Acre yields of cotton and grain sorghums average about two-thirds as much as on Abilene fine sandy loam. This soil works readily and forms an excellent seedbed, and little trouble is experienced in obtaining good stands of crops. Some soil blowing occurs but in general is not severe. The surface relief is gently or moderately sloping, and nearly all areas are materially benefited by proper terracing.

Miles loam.—Miles loam is similar to Miles fine sandy loam. It differs from that soil in that it is slightly heavier in texture throughout the profile. It is slightly more fertile, slightly less drought resistant, and about equally productive. It is a very good soil, nearly all of which is in cultivation, and is devoted primarily to the production of cotton.

The 8-inch topsoil consists of friable granular dark reddish-brown loam. It grades into reddish-brown friable granular clay loam which extends to a depth of about 24 inches where it grades into friable massive red loam. At a depth ranging from 5 to 6 feet is a whitish-colored layer consisting of a mixture of reddish loam and white chalklike carbonate of lime. The light-colored layer is several feet thick and grades down into less highly calcareous yellowish-red loam. The soil material is not highly calcareous from the surface to a depth within a foot or so of the light-colored layer.

This soil, which occupies gently or moderately sloping smooth areas, is of slight extent. A few areas included with this soil in mapping are underlain by weakly bound sandstone. This variation occurs in the same general localities as the similar variation of Miles fine sandy loam.

The entire soil mass is porous and readily penetrated by water and plant roots. The store of plant nutrients is fairly good, and no trouble is experienced with soil blowing.

Miles gravelly fine sandy loam.—Miles gravelly fine sandy loam includes small bodies of soil which are so gravelly as to be generally unsuitable for cultivation. Nearly all such areas are utilized for farm pasture. Small areas, because they occur as spots within fields of good soils, are in cultivation, but on such spots crop yields are in general low.

This gravelly soil, to a depth ranging from 10 to 18 inches, consists of reddish-brown loam or fine sandy loam containing numerous water-worn gravel. This material grades downward into a bed of water-worn gravel which are embedded either in red clay or caliche (hard white carbonate of lime). Typically, no free carbonate of lime is present in the surface layer.

This soil occupies sharp slopes and knolls. The principal areas are several hundred feet above the present bed of Prairie Dog Town Fork Red River, in the vicinity of Williams School in the north-

western part of the county. A few bodies have been utilized as a source of gravel for construction purposes, but the gravel is in general of poor quality.

Enterprise very fine sandy loam.—Enterprise very fine sandy loam is similar to Miles loam, but the surface soil is less dark, the material has no granular structure, and there is no texture profile. This soil occurs as smooth areas surrounded by rough broken land, adjacent to Pease River.

The surface soil consists of reddish-brown or brownish-red faintly calcareous, friable, cloddy, very fine sandy loam which is not granular. Below the 12-inch surface layer the soil material becomes more calcareous and slightly less dark, being a light brownish red very fine sandy loam, which, below a depth of 30 inches, contains numerous white threads and films of carbonate of lime. Nearly all areas of this soil are underlain by beds of water-worn gravel at a depth ranging from 3 to 20 feet.

This is a good soil, and where cultivated it produces good crops of cotton and feed crops. It is of slight extent, and only a small proportion of the land is in cultivation. Some areas are highly valued as a source of gravel for construction purposes.

Miles loamy fine sand.—Miles loamy fine sand differs from Miles fine sandy loam in that it is slightly less dark in the surface soil and somewhat sandier in all soil layers. It is locally known as "red sandy land" and constitutes the most sandy parts of all the land given that designation. It is not so productive as Miles fine sandy loam, as it is less rich in plant nutrients and more subject to soil blowing, but it is fully as drought resistant.

To a depth of about 18 inches the soil consists of reddish-brown mellow and somewhat loose loamy fine sand, which grades downward into red fine sandy loam. This material extends to a depth of about 40 inches, where it grades into reddish-yellow loamy fine sand. The soil material above a depth of about 5 feet contains no free carbonate of lime, but below that depth it is faintly calcareous and white films coat the vertical cracks in the soil.

This is a fairly good soil and is generally well suited to crop production, although it requires careful management to prevent excessive soil blowing. Nearly all the land is in cultivation, and cotton is the principal crop grown. A greater proportion of this land than of Miles fine sandy loam is planted to feed crops. This results from the necessity for the frequent planting of some crop other than cotton, because continuous cultivation to cotton causes excessive soil blowing. This soil occupies gentle slopes and knolls along the margins of the general areas of very loose sandy soils.

Enterprise loamy fine sand.—Enterprise loamy fine sand is similar to and, agriculturally, practically identical with, Miles loamy fine sand. It differs from the Miles soil in that it is somewhat less dark in most areas and has no texture profile, that is, the topsoil is not underlain by heavier textured material.

The soil consists of faintly calcareous brownish-red mellow loamy fine sand which becomes more calcareous and slightly lighter colored with increase in depth. Below a depth of about 2 feet the material is calcareous mellow yellowish-red loamy fine sand containing a few fine white threads of carbonate of lime, which continues downward for many feet without change.

This soil is confined to localities within 3 miles of Prairie Dog Town Fork Red River, and it consists of wind-blown material which has been altered but little since deposition. The areas farthest from the river are slightly darker and are heavier in texture, many of them being loamy very fine sand. They are also the least calcareous and may contain no free carbonate of lime above a depth of about 24 inches. A few included areas have smoother surface relief and have a reddish-brown surface soil.

This is a rather extensive soil, and probably four-fifths of the total area is in cultivation. It is drought resistant, produces cotton and grain sorghums successfully, but is subject to severe soil blowing and requires careful culture and frequent rotation of cotton with a row crop to prevent blowing. Crop yields are about the same as on Miles loamy fine sand and over a period of years do not average more than one-half as much as similar crops on Abilene fine sandy loam.

Yahola loamy fine sand.—Yahola loamy fine sand constitutes the moderately heavy sandy parts of the alluvial bottom land along Prairie Dog Town Fork Red River and Pease River. It is not extensive. The surface soil consists of brownish-red or yellowish-red calcareous loamy fine sand. It is extremely variable and is underlain by sand or by thin strata of clay at various depths. This soil consists of material deposited by the flood waters of the adjacent rivers, and all areas are subject to overflow. In most places the water table lies at a depth of less than 5 feet, and the land is subirrigated. In dry seasons a thin crust of salt, or "white alkali", forms on the surface in many places.

Where this soil is not subject to excessive soil blowing, it produces excellent yields of crops. The water table lies at a sufficiently slight depth that the soil remains moist nearly to the surface all the time, and plants do not suffer from lack of moisture. In most places the quantity of salt present is not enough to damage the general field crops. Most of the areas are utilized as grazing land and have a very high carrying capacity. All this soil occupies positions where the possibility of destruction through shifting of the adjacent river channel is ever present.

VERY LOOSE SANDY SOILS

The soils constituting the group of very loose sandy soils comprise slightly more than one-tenth of the total area of the county. They are locally known as "shinnery sand." They are all very light, loose, and sandy, and two—Enterprise fine sand, dune phase, and Yahola fine sand—are so subject to soil blowing as to be entirely unsuitable for crop land. About one-third of the total area of Miles fine sand and of Enterprise fine sand is in cultivation. Yields on these soils are low, and they decrease rather rapidly according to the length of time the soils have been in cultivation. This feature of rapidly decreasing yields is one which is not generally characteristic of soils in this section. These soils are drought resistant, low in fertility, and very subject to soil blowing when cultivated. The increased soil blowing following a few years' cultivation is one of the principal causes of the decrease in crop yields, although rapid depletion of the small store of plant nutrients is another important cause. With careful management, including the use of green manures, cover crops,

and fertilizers, the land may be used as a part of a farm unit, but these practices have not been tried to a great extent, and their effectiveness is not certain. A few farmers have planted winter rye on spots which were blowing badly, and following the winter growth the rye was plowed under in the spring as a green-manure crop. Under such treatment soil blowing was markedly reduced, and increased crop yields were obtained during the following 2 or 3 years.

A larger proportion of the cultivated land of these soils than of the soils of any other group is planted to feed crops. Cotton is dominant but much less so than on the moderately heavy sandy soils. This slighter dominance of cotton is the result of the necessity for frequent planting to grain sorghums or similar crops in order to lessen soil blowing. On these soils the average yield of corn more nearly approaches that of grain sorghums, and most of the small acreage devoted to corn in this county is confined to these soils. A small acreage is planted to watermelons and cantaloups.

The average acre yield of cotton is one-fifth bale or less over a period of years, and the maximum yield is never much more than one-third bale. Because of poor management and incorrect use, a rather large proportion of the land which was at one time in cultivation has become so drifted and blown that it is unsuited for cultivation, whereas, before breaking, it was good grazing land. The selling price of this land is approximately one-fourth as much as that of the moderately heavy sandy soils. The native vegetation on these soils is dominated by shin oak, sand sage, and little bluestem.

Miles fine sand.—Miles fine sand is the most productive of the very loose sandy soils. In places where the land has never been cultivated, it has a very light loose sandy topsoil about 2 feet thick, which consists, in the topmost 5-inch layer, of brown or dark-brown loose or faintly cloddy fine sand. Below this depth the topsoil is yellowish-brown loose fine sand. The topsoil grades into a heavier subsoil layer which consists of yellowish-red friable loamy fine sand or fine sandy loam. Below a depth of about 3½ feet the material again becomes more sandy and continues downward for many feet without change as reddish-yellow noncalcareous fine sand. As seen in the few deep cuts on this soil, white films of carbonate of lime coat the vertical crevices below a depth ranging from 8 to 10 feet.

This soil is moderately extensive and occurs in two general localities—the sand ridge along Prairie Dog Town Fork Red River and the sand ridge southeast of Chillicothe. It occupies broad areas of gently rolling country. A very large proportion of the rainfall is absorbed by the soil, and little water is lost by run-off.

Enterprise fine sand.—Enterprise fine sand differs from Miles fine sand in that it is not underlain by a heavier textured subsoil. The surface soil consists of a 4-inch layer of brown loose or faintly coherent fine sand which grades into brownish-yellow loose fine sand. At a depth of about 20 inches this grades into yellowish-red fine sand, and at a depth of about 24 inches the material becomes slightly loamy and distinctly red. Below a depth of 4 feet the material is reddish-yellow fine sand which extends downward without change to a depth of many feet. The soil contains no free carbonate of lime. Following cultivation the slightly dark color of the surface soil quickly disappears, and cultivated fields appear yellow or yellowish white.

In general this soil is better suited for use as grazing land than for cultivated crops. Less than one-third of the total area is in cultivation, and the rest is utilized as grazing land. Most of the abandoned fields in the county are on this soil. Through improper use these areas have been subject to serious soil blowing. In some of these the topmost 12 inches of soil has been blown away and piled into dunes in adjacent pastures, leaving the yellowish-red slightly loamy fine sand exposed on the surface. Such blown-out areas are entirely bare of vegetation. It is probable that the soil in such areas if cultivated would blow less than the original soil, and that, by the addition of nitrogen and organic matter, it should be possible to produce fair crops. Under present conditions crops are a complete failure on these spots. Several fields which previously were blowing very badly have been improved by sowing rye, allowing it to grow through the winter, and plowing it under in the late spring as a green-manure crop. Following such treatment yields were almost as good as on freshly broken land. If it be possible to use a legume for the green-manure crop in place of, or in conjunction with, the rye, even greater benefits should be obtained.

Enterprise fine sand, dune phase.—Enterprise fine sand, dune phase, is sand which is so loose as to be entirely unsuitable for cultivation. It consists of brownish-yellow or reddish-yellow loose fine sand extending downward without change to a depth of many feet. Land of this character has a billowy or dunelike surface relief. In most areas the dunes are stationary and covered with a brushy growth of shin oak, wild plum, sumac, sand sage, and some sandgrasses. This kind of land is fair or poor grazing land, but it has no other agricultural value. The greater part of it is included in large livestock ranches.

Yahola fine sand.—Yahola fine sand is the very light sandy bottom land along Pease River and Prairie Dog Town Fork Red River. It consists of soil materials reworked by stream and wind action, and it is too loose and subject to soil blowing to be suitable for farm land. It consists of reddish-yellow calcareous loose fine sand extending to a depth of many feet without soil change. The water table lies within 10 feet of the surface, and some salty condition is apparent in places. The soil is subject to overflow.

The land supports a mixed vegetation of saltgrasses, salt bush, tamarisk, or saltcedar, shin oak, wild plum, cottonwood trees, and many other plants. It is good grazing land, and, agriculturally, its heavier vegetation and greater carrying capacity constitute the difference between this soil and Enterprise fine sand, dune phase.

SHALLOW SOILS

The soils grouped as shallow soils comprise about one-eighth of the total area of the county. This group includes the poorer and shallower areas of "red tight land" and of the soils which are very shallow over gypsum. Average crop yields on these soils are low, and a rough estimate places them at approximately one-half of the yields obtained on the smooth heavy soils. These soils are sloping, subject to erosion unless carefully managed, droughty, and rather infertile. During years of plentiful rainfall, they produce fair or good yields but materially less than do the smoother and darker

soils, and during years when the rainfall is scant, crops are practically a failure. These shallow soils occur most extensively in the belt of sloping land which extends north and south through the central part of the county, and in addition they comprise probably one-fourth or more of the Quanah plain—that part of the county west of Quanah.

These soils constitute marginal or poor crop land, and the greater part of them should be utilized as pasture land, as already a larger proportion of them is in cultivation than is economically justifiable. A few farms consisting of this kind of land have been abandoned and are slowly reverting to native-grass pasture. At present about one-third of the total area of these soils is in cultivation, and to a large extent this consists of spots and small areas included in fields predominantly of smoother and better soils. The land in cultivation is utilized largely for the production of wheat. These soils are generally unsuitable for cotton, as cotton is an expensive crop to grow and, compared with the other general crops of the section, requires too large an amount of labor to be grown on poor land. Where cultivated these soils should be utilized largely for the production of the crop which requires the least investment in time and labor, namely, wheat.

Vernon clay loam.—Vernon clay loam is a shallow type of “red tight land.” The surface soil is only about a foot thick, overlies raw red clay, is droughty, and generally of low productiveness. This is poor land for cropping purposes and should be used as pasture.

The topsoil consists of reddish-brown or brownish-red calcareous compact clay loam or clay ranging from 8 to 12 inches in thickness. This grades below into red, very compact calcareous clay containing a few white spots or concretions of carbonate of lime. This highly calcareous layer extends to a depth of about 30 inches where it grades into less calcareous raw compact red shaly clay. All parts of the soil below the 5-inch surface layer break out in very hard intractable clods which have slick and glistening surfaces when moist. The 5-inch topsoil is slightly less compact and breaks down when dry to rather angular fragments. In the undisturbed virgin areas, the topmost inch or so of soil is reddish-brown friable platy clay loam. In cultivated fields the soil crusts badly and has a very red appearance.

This soil occupies moderate or sharp slopes of more than 3-percent gradient. It is fairly extensive and is widely scattered throughout the western half of the county. It constitutes the poorest land on most of the farms within that section and is largely utilized for pasture. The native grasses provide good grazing. Less than one-third of the total area is in cultivation. During most years cotton is a failure on this kind of land, and the cultivated land is largely sown to wheat. The average acre yield of wheat over a period of years is less than 10 bushels.

A few areas included in mapping are yellowish brown but are otherwise similar to the typical soil. The principal areas of this variation lie a few miles south of Lake Pauline.

Weymouth clay loam.—Weymouth clay loam differs from Vernon clay loam in that it is granular and more friable. The color is typically somewhat less red, and the carbonate of lime zone beneath the

soil is much thicker, whiter, and better developed. This is a sloping shallow soil which constitutes poor land for cropping purposes.

The 10- to 15-inch topsoil consists of reddish-brown calcareous granular and friable clay loam. It overlies a light-colored layer consisting of a mixture of light-brown clay loam and white carbonate of lime. Although this layer contains no gypsum it is commonly known as "gyp." The light-colored layer in most places ranges from 1 to 2 feet in thickness and grades downward into less highly calcareous material. In places this material overlies partly weathered limestone bedrock, and here the light-colored layer is nearly pure carbonate of lime and contains very little earthy material. Hardened irregular nodules, or "gravel", of carbonate of lime are scattered over the surface and throughout the soil. This shallow soil is readily permeable to moisture and plant roots. The substratum, below a depth ranging from 2 to 3 feet, is compact. Worm casts are abundant throughout the soil material.

This soil is moderately extensive and occurs widely scattered throughout the western two-thirds of the county. It is somewhat more productive and less tight and droughty than Vernon clay loam, but it is poor crop land and for the most part should be used for pasture. The native sod on this land constitutes good pasture. About one-fourth of the total area is in cultivation.

Weymouth very fine sandy loam.—Weymouth very fine sandy loam is a shallow red sandy soil overlying sandstone. The 10- to 15-inch topsoil consists of brownish-red friable granular very fine sandy loam. It grades into rotten or partly disintegrated red sandstone which contains white streaks and spots of carbonate of lime. The content of carbonate of lime slowly decreases with depth, and unweathered red slightly calcareous sandstone occurs at a depth of about 6 feet below the surface. Fragments of the red sandstone and of hardened white concretions are scattered thinly over the surface and throughout the soil.

This soil is of slight extent. It occurs chiefly as a rim around the margins of the flats in the vicinity of Star Valley School about 10 miles south of Quanah, and a few typical areas are a few miles north of Chillicothe. The areas mapped as this soil on the southern edge of Chillicothe are an included variation of brown soil overlying caliche (hard white carbonate of lime) and not red sandstone.

This soil is shallow, droughty, and rather infertile. Most areas have a slope of more than 3 percent. A small proportion of the land, consisting of small spots within fields of deeper soils, is in cultivation. This is poor land for cropping purposes, however, and in general should be utilized as pasture.

Acme clay loam, shallow phase.—Acme clay loam, shallow phase, is a very shallow soil and overlies gypsum. It consists of dark-brown very friable and very granular calcareous clay loam or clay, which rests abruptly on white nearly pure gypsum at a depth ranging from one-half inch to 24 inches. The soil, so far as soil exists, is very fertile, friable, and excellent; but in most places the soil material is very shallow, and this kind of land is poor and unsuitable for cropping. Most of the material within reach of plant roots is gypsum, which is neither harmful nor of any value to plants. The

soil has a very low water-holding capacity, as the shallow spots are very droughty.

This soil is utilized as grazing land or as a source of gypsum for industrial purposes. It is inextensive, and the principal areas occur in the vicinity of Acme. A large proportion of the land is flat and dotted with small "gyp sinks" or caves. A rather large part of the area mapped in the vicinity of Acme has been surface worked for gypsum and now consists of alternate pits and dumps of overburden.

ROUGH LAND

This group includes soils and land types that are extremely rough or stony. It comprises more than one-fourth of the total area of the county. Its only value is as grazing land, and most of it is held within large livestock ranches. Land of this character occupies the breaks of Pease River and occurs elsewhere in smaller areas.

Rough broken land.—The land type, rough broken land, designates areas of extremely dissected and broken land. Dominantly the land so classified is the severely eroded land bordering Pease River. East of the highway bridge across Pease River the areas in the breaks consist of eroded droughty red clay which supports a very scant native vegetation and has a very low value for grazing. West of the highway bridge the areas are much more stony or gypsiferous and are covered with a scrubby growth of cedar which has some value for fence posts and fuel. With the exception of scattered patches of grass growing in the bottoms of gullies, the vegetation provides very little grazing. As mapped, rough broken land includes the deep-gullied channels of the larger creeks, which are lined with hackberry trees and support a heavy growth of short grasses.

Vernon clay, eroded phase.—Vernon clay, eroded phase, includes areas of eroded red clay, which are not extremely broken. The material consists of red calcareous very compact raw clay which is geological material and has not developed into a soil. This type of land is extremely droughty, vegetation is scant, and during dry years the material blows badly. The land is entirely unsuitable for cultivation. The difference between this land and rough broken land is that the Vernon soil is smoother, supports a little more grass, and is somewhat better grazing land.

Miller clay, colluvial phase.—Miller clay, colluvial phase, consists of very compact calcareous red clay. It constitutes the gullied red flats along the short tributary streams in the breaks of Pease River. The soil is very tight and compact and consists largely of raw clay of the exposed "Red Beds" formations, which has been washed down from adjacent areas of rough broken land. It is much less fertile than typical Miller clay as mapped in other counties. Although small bodies might be cultivated, they would probably be unproductive and extremely droughty. Most of the areas are badly cut with a network of gullies, and they occur in isolated localities. This land should continue to be used for grazing, as it supports a fairly heavy growth of tobosa grass, saltgrasses, some buffalo grass, and a heavy growth of mesquite brush. It is good grazing land and ranks higher in carrying capacity than rough broken land.

Weymouth stony loam.—Weymouth stony loam consists of rather smooth areas where limestone bedrock outcrops or lies within a few inches of the surface. It is most extensive in a broad belt of sloping country extending north and south across the county just east of Quanah, and it also occurs throughout the western half. The soil ranges from 2 to 6 inches in thickness and consists of brown or dark-brown friable loam or clay loam filled with fragments of stone. It overlies beds of sedimentary limestone which is covered largely by caliche. Areas of this soil support a good growth of short grasses, dominantly needlegrasses and gramas. The land affords good grazing and is utilized as pasture. Much of it is held within large live-stock ranches.

River wash.—River wash comprises the dry sand beds and banks of Pease River and Prairie Dog Town Fork Red River. It is bare of vegetation and has no agricultural value. It consists of loose fine sand which is subject to occasional overflow and shifting by water and by wind.

SOILS AND THEIR INTERPRETATION

Hardeman County lies in the southern part of the Great Plains region within the belt of Chernozem (black-earth) soils. The soils occupying the smooth areas have very dark brown or dark reddish-brown surface horizons. They are as dark as, or darker than, the normal or mature soils of any other equally warm section. The soils of this county have been developed under a warm subhumid climate which favored a rather heavy growth of plains short grasses and rather rapid decomposition of organic matter. The dark color is imparted by finely divided organic matter derived from the decay of grass roots or other plant remains and mixed with the mineral constituents. Although the organic matter is rather evenly distributed throughout the soil, it is slightly more abundant on the outsides of structure particles, and it gradually decreases with depth. The smooth well-developed clay loams contain between 2 and 3 percent of organic matter in the 12-inch surface layer and somewhat smaller quantities in the lower layers. Comparable fine sandy loams contain approximately one-half as much organic matter. The estimates of organic-matter content are based on the nitrogen content of the soils of this section, which is reported in Texas Agricultural Experiment Station Bulletin 443.⁷ The indication of comparatively low content is supported by the determination of the organic-matter content of Pullman silty clay loam (reported as Amarillo silty clay loam) in United States Department of Agriculture Technical Bulletin 228.⁸

Owing to the limited rainfall in this section, no strong downward movement of water through the soil and substrata takes place, and below a depth ranging from 3 to 4 feet in the clay loams, or somewhat deeper in the sandy soils, the soil material is permanently dry. Accordingly the bases have not been strongly leached out of the soils, and all the soil material has a nearly neutral or alkaline reaction.

⁷ FRAPS, G. S. CHEMICAL COMPOSITION OF SOILS OF NORTHWEST AND WEST-CENTRAL TEXAS. Tex. Agr. Expt. Sta. Bull. 443, 25 pp. 1932. See pp. 19-24.

⁸ ANDERSON, M. S., and BYERS, H. G. CHARACTER OF THE COLLOIDAL MATERIALS IN THE PROFILES OF CERTAIN MAJOR SOIL GROUPS. U. S. Dept. Agr. Tech. Bull. 228, 24 pp. 1931. See p. 5.

The clay loams have no texture profile, but the well-developed sandy soils have a slightly developed texture profile. The slightly soluble salts, essentially calcium carbonate, which were originally present in the parent materials or which were formed during the soil-development processes, have been leached from the surface soils, carried down to the depth of frequent penetration of soil moisture, and redeposited as a zone of carbonate concentration. The sandy soils have developed a pronounced reddish color, but the heavy soils have done so to much less extent or not at all. The loosest deep sands have been thoroughly leached and have no accumulation of calcium carbonate in the solum.

The geological strata from which the present soils have developed consist dominantly of unconsolidated deep-red slightly calcareous shaly clay, the Permian "Red Beds." This material is an old sea deposit and contains a rather high content of sodium chloride and other salts. The exposed section includes a rather large quantity of gypsum which occurs in several local beds and reaches a maximum thickness of 20 feet. It also includes about seven thin strata of limestone or dolomite which range from 6 inches to 3 feet in thickness. One of the lower beds exposed in the southeastern part of the county is a red weakly bound sandstone which embraces approximately the upper 200 feet of the Clear Fork and the lower 500 feet of the Double Mountain formations of the Permian series.⁹

In a belt ranging from 2 to 5 miles in width along Prairie Dog Town Fork Red River and in an area on the southeastern edge of Chillicothe, the Permian "Red Beds" are overlain by a deposit of unconsolidated sand which contains some water-worn gravel and which reaches a maximum thickness of at least 50 feet. This material is much younger geologically and is largely an old fresh-water stream deposit. The principal physical difference between this material and that of the Permian "Red Beds" is that it consists more largely of sand. The part occurring within a mile or two of Prairie Dog Town Fork Red River is largely material that has been carried in by winds.

Although the climate and especially the native vegetation are the chief controlling factors in soil building, the different geological materials have influenced the soil-development processes and have given rise to differences among the soils. The greatest influence of the parent material is reflected in the texture of the resultant soil, which, under the dominant soil-building process of the region, is approximately the same as that of the geological material. The other important influence of the parent material is reflected in the structure and friability of the soil. The sandy soils are all friable and easily permeable, and, unless extremely sandy, have developed a good granular structure; the heavy soils derived from the dominant red shaly clays are compact and are only slightly granular; and the soils of heavy texture derived from parent materials containing a large quantity of calcium (in the form of carbonate and sulphate) or from fresh-water sediments are friable and are very granular. The friable and granular type of soil profile, which is the normal Chernozem profile, is exhibited in well-developed or mature form by the

⁹ UDDEN, J. A., BAKER, C. L., and BOSE, E. REVIEW OF THE GEOLOGY OF TEXAS. *Tex. Univ. Bull.* 44, 164 pp., illus. 1916.

Abilene, Miles, and Acme soils. The compact type of profile which may be designated as "abnormal Chernozem" is exhibited in well-developed form by the Hollister and Tillman soils. Although the compact type of profile is termed abnormal, it is the dominant type in the smooth soils of heavy texture throughout some sections of western Texas.

Both the Miles and the Abilene series include soils overlying and derived from fresh-water deposits and also from the Permian "Red Beds", a marine deposit. The clay loam types of these series are developed mostly from the Permian "Red Beds", under some influence, locally, of an accumulation of colluvial material. The other members of these two series are derived from ancient fresh-water deposits. As mapped the loams and fine sandy loams of both series include a few areas underlain by sandstone.

The Abilene soils are nearly black or dark-brown friable and granular normal mature Chernozems, and they represent complete soil development for this section. They occupy smooth nearly flat well-drained areas. The following description of a profile of Abilene clay loam typically represents these soils. This profile was observed 5 miles southwest of Chillicothe, on a nearly level well-drained flat covered by a dense sod of plains short grasses, dominantly buffalo grass.

- 0 to 1½ inches, dark grayish-brown friable platy silty clay loam or silt loam, which does not effervesce with hydrochloric acid. The plates are thin at the surface and thicker and less well defined in the lower part. Worm and insect casts are abundant.
- 1½ to 10 inches, very dark brown or nearly black friable granular clay. The material breaks into irregular clods which are aggregates of somewhat rounded granules about one-eighth inch in diameter, and on drying these separate readily. The outsides of the granules are dull black and the interiors are dark brown. The material is porous, plant roots penetrate throughout the mass, and worm casts are abundant.
- 10 to 24 inches, dark-brown granular friable clay of similar structure as the material in the overlying layer.
- 24 to 36 inches, grayish-brown calcareous friable clay which breaks into friable clods and small angular fragments. The material contains numerous worm casts and a very few soft or semihard concretions of calcium carbonate. Plant roots are few but penetrate throughout the mass. The material is porous, permeable, and is filled with a fine threadlike network of open tubes representing old root channels.
- 36 to 54 inches, the zone of carbonate accumulation. The material consists of grayish-brown highly calcareous friable clay which contains about 30 percent of soft or semihard irregular-shaped whitish concretions of calcium carbonate. The material breaks out as irregular massive crumbly clods. The color of the mixed material has a distinctly white cast.
- 54 to 84 inches +, compact calcareous dark-gray clay containing streaks and vertical tongues of white calcium carbonate. The material in this layer is less highly calcareous than that in the layer above. It breaks apart as vertical columns, from 1 to 1½ inches in diameter, with flat faces coated with lime. Below a depth of 84 inches the material is reddish yellow and is somewhat sandy.

The profile described occurs at the margin of a belt of higher lying sandy soils, and the high content of carbonate of lime in the parent material in this place is apparently caused as a ground-water deposit. This soil is also developed in flat locations where the high content of carbonate of lime is caused by the occurrence of a limestone bed. Such an area occurs on the high flat top of an outlier about 1 mile west of Herg in the western part of the county.

The Abilene soils mapped in Hardeman County are friable throughout their profile and do not exhibit a moderately compact layer from a depth of 18 inches down to the zone of carbonate accumulation such as is characteristically developed in the type locality of these soils—the section around Abilene, Tex.

The Miles soils are friable and granular like the Abilene soils, but they are redder and less dark colored, owing to their more sloping surface relief, and in part to their sandier texture. They are not subject to much erosion. They are dark reddish-brown friable and granular normal Chernozem soils. The sandy and medium-textured members have a moderately developed texture profile, but the clay loam has none. These soils are underlain by, and have been developed from, unconsolidated sands or highly calcareous clays.

Acme clay loam is practically identical with Abilene clay loam except for the difference in the underlying substrata. It is a nearly black friable and granular normal Chernozem underlain by gypsum. The material in all the soil layers is calcareous, the granular character of the surface layers is slightly better developed than in Abilene clay loam, and the material in the layers below a depth of 24 inches is slightly more crumbly and friable. These slight differences are due to differences in the parent materials.

The Hollister soils are the darkest colored members of the group of compact soils. They are nearly black soils which are moderately friable material in the surface layer and grade downward into compact material, but they are not claypan soils. They are intermediate in character between the granular Abilene soils and the claypan Foard soils mapped in Wichita County, Tex. The essential features of these soils are given in the following description of a profile of Hollister clay loam, as observed 2 miles west of Quanah, 0.4 mile west of the southeast corner of survey 193, block H, on a smooth well-drained flat covered by a dense sod of plains short grasses consisting dominantly of buffalo grass:

- 0 to 1½ inches, dark grayish-brown platy silty clay loam which contains numerous worm and insect casts, is friable, and readily crumbles to a fine powder. The plates are fragile and rather indistinct. They are very thin near the surface but become thicker with depth.
- 1½ to 10 inches, nearly black moderately granular friable clay. This material breaks when dry into crumbly clods which break down to somewhat rounded or subangular granules about one-eighth inch in diameter. The exteriors of the granules are dull black, and the interiors are very dark brown. The soil material is porous, and plant roots permeate throughout the mass. It contains a few worm casts.
- 10 to 24 inches, very compact calcareous dark-brown clay that breaks apart into very hard and compact irregular clods which cannot be crushed between the fingers when dry. The broken surface has a glistening or slick appearance when moist. This layer contains no worm casts, and plant roots are most abundant along the natural soil crevices. The dominant breakage is vertical.
- 24 to 46 inches, brown calcareous very compact clay containing a very few small white concretions of calcium carbonate. The structure of the material is similar to that in the overlying horizon.
- 46 to 54 inches, the carbonate zone which consists of brown highly calcareous compact clay containing about 10 percent of somewhat rounded soft white concretions of calcium carbonate about one-half inch in diameter.

As observed in other places, the carbonate zone is several feet thick and the brown color persists downward to a depth of about

10 feet. The carbonate of lime concretions become larger and less abundant with depth. The unchanged slightly calcareous deep-red shaly clay of the Permian "Red Beds" underlies this soil below a depth of 10 feet.

In addition to a very slight difference in texture, Hollister clay differs from Hollister clay loam in that it is not granular in the surface layer. The material, to a depth of about 6 inches, breaks, when dry, into small angular fragments, but below that depth it is very compact. The compact character of these soils is probably caused by the presence of sodium chloride in the parent material. The soils represent full development from their parent materials, although they are abnormal soils and not normal Chernozems.

The Tillman soils are the reddish equivalents of the Hollister soils and are identical in structure with Hollister clay loam. They are dark reddish-brown soils which are somewhat granular in the 12-inch surface layer and grade downward into very compact material. They are underlain by, and have been developed from, the deep-red slightly calcareous shaly clays of the Permian "Red Beds" on gently sloping surface relief. The reddish color is largely inherited from the geological material and is not a developed soil color, as is shown by the dark yellowish-brown color of these soils in a few places where the original parent materials were not red. The redder color of the Tillman soils is largely the result of less masking by the black color imparted by organic matter.

The Vernon soils are shallow calcareous compact reddish-brown or brownish-red soils. They have developed from the Permian "Red Beds" on slopes where the run-off is so great that less water is available for plant growth and consequently less for soil development than on the more nearly level areas. On such sloping land there is more than the normal amount of erosion. These soils have a slightly developed carbonate zone about a foot below the surface. Their red color is inherited from the parent material and is not a developed soil color.

The Weymouth are shallow granular soils. In addition to the difference in structure, Weymouth clay loam is less red and has a carbonate zone which is whiter and contains much more lime than that of Vernon clay loam. The Weymouth soils are shallow immature soils which are developing in a normal manner. They have developed from highly calcareous or sandy parts of the Permian "Red Beds."

The Enterprise soils are wind deposits of soil material which is largely unchanged. Development of a profile is very slight and consists of a slight darkening of the surface layer and a slight leaching of the carbonates from the surface material. These soils differ from the Miles soils in that they have no texture profile, are less dark, and have not developed a granular structure. They are much less mature than the Miles soils.

SUMMARY

Hardeman County includes an area of 693 square miles in northern Texas on the Rolling Plains, a division of the Great Plains. The elevation ranges from 1,200 to 1,825 feet above sea level. About one-

fourth of the county is rough, and the rest of the land ranges from rolling to flat.

The climate is warm and subhumid. The average annual rainfall is nearly 25 inches, and soil moisture is in general the limiting factor in crop production.

Approximately 300 square miles, or 40 percent of the county, including practically all of the good soils and some marginal land, were in cultivation in 1932. Cotton and wheat constitute the cash crops. Cotton occupies about three-fifths of the land in cultivation, grain sorghums and sorgo about one-fourth, and wheat about one-seventh. The average acre yield of cotton over a period of years is slightly less than one-third bale, of grain sorghums about 15 bushels, and of wheat about 12 bushels. Approximately one-fourth of the land is included in livestock ranches which are devoted to the production of high-grade Hereford beef cattle.

About one-third of the county consists of smooth heavy soils which produce good yields of cotton and excellent yields of wheat; about one-sixth consists of moderately sandy soils which produce excellent yields of cotton; about one-eighth consists of very sandy soils which are poor crop land and produce low yields of cotton and grain sorghums; and about one-eighth consists of shallow droughty soils which are poor crop land producing low yields of wheat and unsuitable for cotton. The remainder (about one-fourth) consists of rough or stony land entirely unsuitable for cultivation.

The smooth heavy soils have dark-colored surface soils, are neutral in reaction, and are underlain by a zone of carbonate accumulation. The county lies within the southern part of the Chernozem (or black-earth) belt. The geological formations from which the present soils have developed consist of unconsolidated sands and clays.

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